WATER QUALITY EVALUATION

OF

ATIKWA (DEER) LAKE

DISTRICT OF KENORA

1970

by

M. J. German

Biology Branch

Division of Laboratories

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SUMMARY

During the summer of 1970, shoreline activities at the southwest corner of Atikwa Lake were underway to develop a base-metal ore body for mining and milling.

On July 8 and 9, a pre-operational survey was carried out on Atikwa Lake and downstream waters in order to document baseline chemical and biological conditions for purposes of future water quality monitoring. The physico-chemical and biological conditions of Atikwa, Eliza and Caviar lakes clearly define the lake to be oligotrophic in nature.

In order to ensure that the excellent quality of these waters be maintained and their aquatic life be protected, treatment of wastes from the proposed land-use should be adequate to satisfy the Commission's criteria for the protection of fish and wildlife, particularly those criteria which pertain to toxic substances and pH.

The report lists specific water quality criteria necessary to protect the fishery resources of Atikwa Lake and contiguous waters. The stringent nature of these criteria demonstrate the necessity for maximum possible reuse of process water. The water quality criteria cited in this report should be applied at a selected monitoring site and owing to the conservative nature of metals and dissolved solids, a consideration of the loading volume for the various waste constituents relative to the water volume and throughput characteristics of Atikwa Lake is essential. These assessments will ensure the future protection of the receiving waters from accumulations of these constituents to sub-lethal levels affecting fish production.

NATURE OF PROPOSED MINING DEVELOPMENT

In January 1970, Maybrun Mines Limited commenced development of mining and milling facilities for the purposes of extracting copper and gold concentrates from an orebody located at the southwest corner of Atikwa Lake. The operation was to commence production in 1970 with an initial milling capacity of 500 tons of ore per day. The orebody, which is predominantly chalcopyrite ($CuFeS_2$), with some intrusions of pyrite (FeS_2) and pyrrhotite (Fe_7S_8), is to be mined by open-pit methods. The mine life is expected to be approximately five years.

While the proposed open-pit method of mining will preclude the possibility of acidic mine-drainage water problems often associated with underground mining, milling wastes, if improperly handled, could create serious impairment of Atikwa Lake and downstream waters. One of the most serious potential effects of milling wastes in the aquatic environment is the generation of acid resulting from the oxidation of gangue sulphide. A simplified version of the reaction is as follows:

$$4\ FeS_2 + 15O_2 + 14H_2O \ \text{--}\ 4\ Fe\ (OH)3 + 16\ H^+ + 8SO_4^{\ 2-}$$

Hydrogen ions liberated by this reaction could lower the pH of the receiving waters which in turn would seriously affect aquatic life. In addition to acid generation, milling wastes are characteristically high in dissolved solids, especially sulphates, and contain heavy metals which could have harmful osmotic and/or toxic effects on aquatic organisms, including fish.

The proposed method of handling mill wastes is to utilize a gully immediately west of the mine. An impervious dyke or dam is to be constructed across the mouth of the gully to prevent the escape of tailings to the lake. A recycle system will then return the supernatant waters from the tailings impoundment area back to the milling circuit,so that no liquid wastes will normally decant to the lake. Any excess supernatant waters will be treated before discharge, if this is required, to ensure compliance with OWRC objectives. Provided these conditions are all satisfied, the mining operations should have no influence on the water quality of Atikwa Lake.

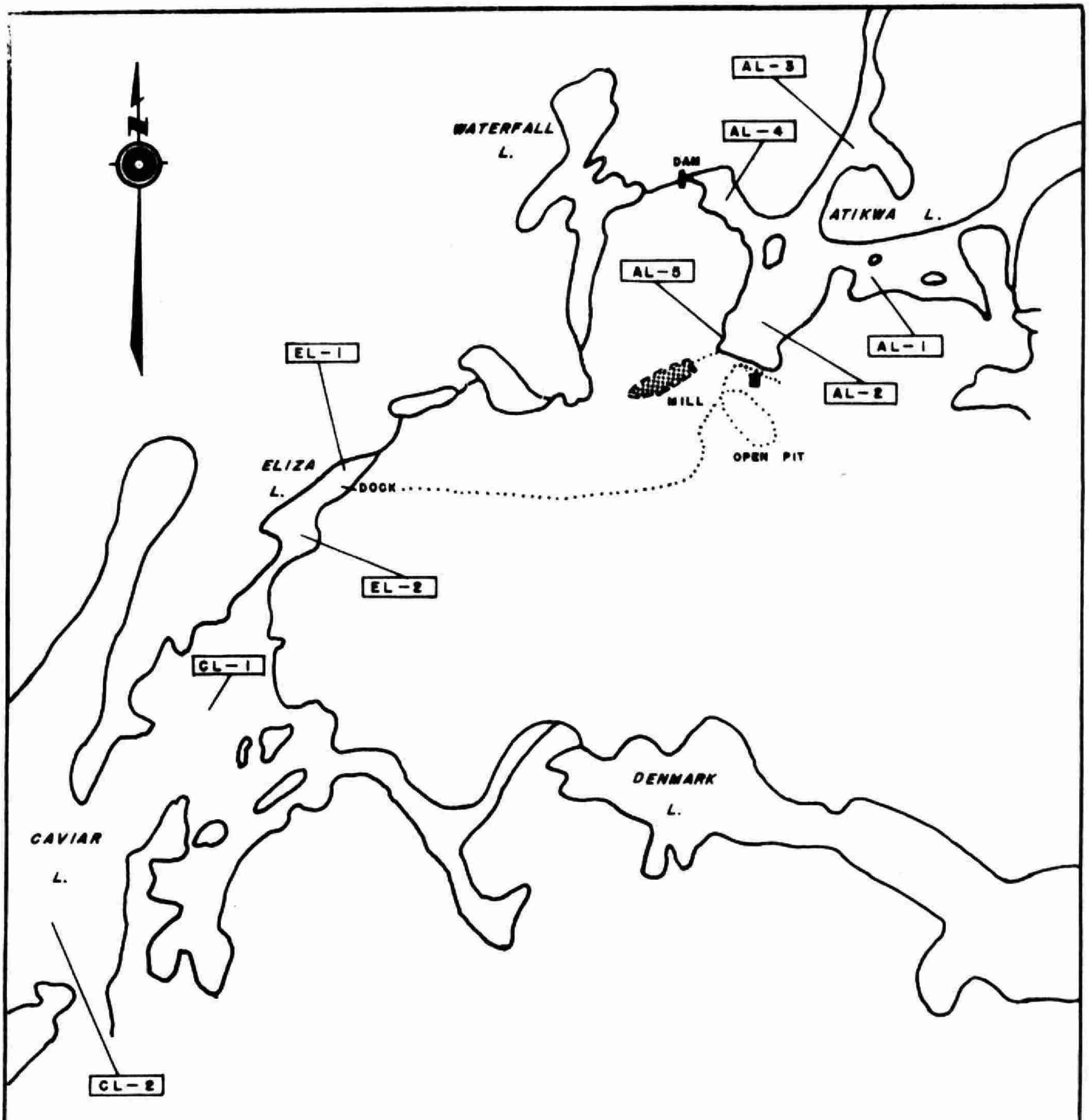
METHODS

The data reported herein were produced from a single visit to the study area on July 8 and 9, 1970. Sampling was carried out at five locations on Atikwa Lake and two locations on each of the downstream lakes Eliza and Caviar. Locations of these sampling sites are illustrated in Figure 1.

Sampling at Station 2 on Atikwa Lake was carried out at ten-foot intervals from surface to bottom. Only surface and bottom samples were collected from the remaining stations.

Measurements of water transparency, temperature, dissolved oxygen and specific conductivity were taken at each sampling site. Water transparency was measured with a Secchi disc.

Temperature readings were made using a telethermometer. Dissolved oxygen concentrations were determined using the azide modification of the Winkler method. Conductivity measurements were read from a field meter.



LEGEND

CL-2 — SAMPLING STATION

— PROPOSED TAILINGS AREA

— LODGE

ONTARIO WATER RESOURCES COMMISSION	
ATIKWA AND CAVIAR LAKES	
SCALE : 1 0 1 MILE	
DRAWN BY : L. L. BROOME	DATE FEBRUARY, 1971
CHECKED BY : D.W.F.	DRAWING Nº : 71-15-BL

Water samples for detailed chemical analyses were secured with a Kemmerer water sampler. Analyses for heavy metals were made on water samples collected in plastic containers and preserved with nitric acid at the time of sampling. All other chemical determinations were made on unpreserved samples shipped in glass containers.

Composite phytoplankton samples were taken from the euphotic zone at each of the sampling locations. The euphotic zone was determined as twice the Secchi disc reading. Samples were preserved with Lugol's iodine and submitted to the OWRC laboratory at Toronto for identification and enumeration.

Five bottom fauna samples were secured at Station 2 on Atikwa Lake by means of a 9 x 9 inch Eckman dredge. At each of the remaining sampling sites, two bottom fauna samples were secured. Dredge samples were washed through a 24-mesh-per-inch (0.0256 inch opening) sieve and the organisms were separated and removed from extraneous materials. The specimens were then preserved in ethanol and returned to the laboratory for identification and enumeration.

RESULTS

Physico-chemical data secured at each sampling site are summarized in Table 1. Table 2 provides the results of detailed chemical analyses carried out at the laboratory. Data on standing crops of phytoplankton and bottom fauna populations are provided in Table 3 and Table 4, respectively.

Temperature

Distinct layering of waters was evident in both deep water lakes, Atikwa and Caviar. At Station 2 on Atikwa Lake, the temperature change from surface to bottom was 36°F and a well-defined thermocline or zone of rapid temperature change was detected between 10 and 20 feet, where the water temperature decreased by 13°F. In contrast, the waters of Eliza, a shallow lake, were homothermous.

Dissolved oxygen

The dissolved oxygen regime of Atikwa, Eliza and Caviar Lakes was typical of oligotrophic lakes in the Precambrian Shield of Northern Ontario. In general, all depths at each of the sampling sites contained an adequate supply of oxygen to support normal aquatic life. The lowest concentration of oxygen, 7 mg/l, occurred at a depth of 35 feet at Station 4 on Atikwa Lake.

At stations closest to the mining development (#2 and #5), the oxygen concentration remained constant at 9 mg/l from surface to bottom. However, at these same locations the degree of oxygen saturation, which is temperature-dependent, ranged from 100 per cent in the epilimnetic water to 82 and 75 per cent in the hypolimnetic waters at station 5 and 2, respectively. Similar saturation deficits were characteristic in the hypolimnetic water at each of the sampling sites.

Water quality

The oligotrophic nature of the lakes under study is clearly reflected in the chemical results. Characteristically, these waters are low in dissolved solids content,

poorly supplied with nitrogen and phosphorus nutrients and virtually free of heavy metals. Further, all of the lakes have waters with a very low alkalinity but a pH slightly on the alkaline side of neutrality. The low alkalinity which is a characteristic of most lakes in the Precambrian Shield of Northern Ontario is an indication of the poor buffering capacity of the study waters. This is significant since the wastes which will result from the mining development will have a high potential for acid generation.

Phytoplankton

Generally speaking, the total a.s.u. (areal standard unit) values for the three lakes can be considered as extremely low and characteristic of many summer-time levels for oligotrophic lakes of Northern Ontario.

Species composition in the lakes was similar as most samples were dominated by the diatoms *Tabellaria* and *Asterionella* and the flagellates *Dinobryon* and *Chlamydomonas*. The genera observed were very similar to those encountered in Dunlop Lake during the mid-summer months of 1966, 1967 and 1968. Dunlop Lake has been classified as oligotrophic to mesotrophic (Johnson *et al*. 1969).

Variations in a.s.u. values between sampling sites within each lake were minor; however, some variations in a.s.u. estimates existed between lakes. For example, total a.s.u. per ml in Atikwa Lake ranged between a low of 194 a.s.u. per ml at Station 5 and a high of 240 a.s.u. per ml at Station 3. These values were slightly lower than those of Caviar Lake yet higher than those of Eliza Lake. It is probably that these "between-lake" variations are related to basic morphometric differences, (i.e.surface area, maximum and mean depths, slope of shoreline, slope

of lake bottom, etc.).

Bottom fauna

Sixteen taxa of bottom fauna, which represent most of the macroinvertebrate forms common to lakes of Northwestern Ontario, were secured from the sediments of the three lakes.

Thirteen of these forms were represented at the shallow water stations 1 and 2 on Eliza and Station 5 on Atikwa Lake. The communities at these locations were dominated by midges of the families Tendipedidae and Heleinae and mayflies of the genus *Hexagenia*.

The communities at the deep water stations 1 and 2 on Caviar Lake and 1 to 4 on Atikwa Lake were less diverse than the shallow water communities. Midges of the family Tendipedidae, the phantom midges *Chaoborus* and scuds, *Pontoporeia affinis*, dominated the deep water community. The presence of *P. affinis* provides further indication of the trophic state of the lakes. It is a species indigenous to oligotrophic and mesotrophic lakes.

Fish

During August, 1960, the Ontario Department of Lands and Forests carried out a fisheries inventory of Atikwa Lake using minnow seines and gill nets. Findings of the survey revealed the presence in Atikwa Lake of the following species: lake whitefish, *Coregonus clupeaformis*; cisco, *Leucichthys* sp.; lake trout, *Cristivomer namaycush*; white sucker, *Catostomus commersonnii*; redhorse *Moxostoma* sp.; Northern pike, *Esox lucius*; yellow walleye, *Stizostedion vitreum*; ling, *Lota lota*; sunfish, *Lepomis* sp.; yellow perch, *Perca flavescens*, and blunt-nosed minnows, *Pimephales notatus*.

According to the report, Atikwa Lake had been fished commercially prior to 1960. The main attraction to anglers are walleye, pike and lake trout.

RECOMMENDED CRITERIA

In June of 1970, the OWRC released its 'Guidelines and Criteria for Water Quality Management in Ontario'. In keeping with the intent of the policies contained therein, the development of mining operations in the vicinity of Atikwa Lake must be consistent with the protection of existing uses. Since high quality angling in Atikwa Lake and adjacent waters has been demonstrated, stringent controls are essential to protect the fishery resources and to preserve the quality of the area for present and future development.

Past experience has clearly indicated the extreme vulnerability of poorly buffered waters to reduced pH, increases in toxic metal concentrations and substantial increases in dissolved solids content. The failure of initial pH adjustment to prevent permanent mitigation of pH effects has underlined the necessity to ensure complete oxidation of acidic wastes prior to discharge. In a number of situations acid generation in the receiving water has resulted from continued oxidation of sulphides and other compounds.

Adequate maintenance of the existing high quality in Atikwa Lake necessitates application of the following pertinent water quality criteria.

Criteria *	Value (calculated 'no effect' levels)
pH **	6.5 to 8.5 (precise value to be determined)
Ammonia	0.5 mg/l
Copper	.0015 mg/l
Iron	.5 mg/l
Lead	.02 mg/l
Manganese	1 mg/l
Nickel	.08 mg/l
Zinc	.02 mg/l
Cadmium	No discharge acceptable in excess of 0.005 mg/l
Mercury	No discharge acceptable in excess of 0.005 mg/l

* These criteria should be applied at a selected monitoring site.

** Adequate controls of acidic discharges or substances having a latent potential to cause subsequent pH depression in the receiving water system must be maintained.

In order to meet these somewhat stringent requirements considering the poor buffering capacity of Atikwa Lake, maximum possible reuse of process water appears to be necessary.

Also, in order to assure the future protection of the lake, a consideration of loading volumes for the various waste constituents relative to the volume of Head Bay (the receiving portion of Atikwa Lake) and Atikwa Lake proper would be essential. In addition, water retention times in Atikwa Lake should be assessed in light of waste loading forecasts. Such an evaluation would permit an estimation of the accumulating potential of conservative metals wastes and dissolved solids which, in turn, would govern the length of time that such elements could be discharged.

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Report prepared by:

M. J. German

M. J. German,
Biologist.

Report approved by:

C. F. Schenk

C. F. Schenk, Supervisor
Biology Branch.

Table 1. Physico-chemical data collected for Atikwa Lake and downstream waters, July 9, 1970.

Station	Depth ft.	Secchi Disc ft.	Conductivity (micromhos/cm)	Temp. °F.	Dissolved oxygen (ppm)	Saturation (%)
ATIKWA LAKE						
1	0	15	46	72	8.0	90
	50		35	48	8.0	69
2	0	16	48	72	9.0	>100
	10		47	72	9.0	>100
	20		42	59	9.0	88
	30		38	54	9.0	83
	40		37	48	9.0	77
	50		42	48	9.0	77
	60		37	46	9.0	75
3	0	15	48	72	8.0	90
	40		45	66	8.0	85
4	0	15	48	72	8.0	90
	35		35	50	7.0	62
5	0	16	48	71	9.0	>100
	30		38	53	9.0	82
ELIZA LAKE						
1	0	9	64	75	8.0	94
	11		56	74	8.0	92
2	0	9	57	75	9.0	>100
	11		57	75	8.0	94
CAVIAR LAKE						
1	0	12	57	73	9.0	>100
	100		57	59	9.0	88
2	0	12	59	73	9.0	>100
	55		52	52	9.0	81

Table 2. Results of chemical determinations made on water samples collected from the Atikwa Lakes chain on July 8 and 9, 1970. All values except pH and turbidity are reported as parts per million.

	ATIKWA LAKE													
	1		2						3		4		5	
	S	B	S	10'	20'	30'	40'	50'	S	B	S	B	S	B
Total Solids	54	54	54	50	58	74	64	76	64	54	70	58	52	60
Susp.Solids	3	1	1	2	2	2	3	1	1	3	2	1	2	2
Diss.Solids	51	53	53	48	56	72	61	75	63	53	68	57	50	58
Turbidity	.6	.4	.5	.6	.7	.5	.6	.8	.6	.8	.5	.6	.6	.5
Sulphates	<5	<5	<5	<5	<5	5	5	5	7	8	8	5	<5	<5
Free Ammonia	.02	.04	.02	.01	.01	.02	.01	.04	.02	.02	.00	.02	.02	.02
Total Kjeldahl	.30	.29	.21	.24	.30	.22	.19	.24	.18	.26	.25	.26	.35	.30
Nitrite	.006	.003	.003	.003	.002	.002	.002	.003	.004	.003	.003	.003	.003	.003
Nitrate	.02	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00
Total Phosphorus	.012	.016	.007	.008	.010	.010	.013	.016	.01	.018	.02	.016	.011	.012
Alkalinity	17	17	17	17	17	17	17	17	15	19	17	19	17	17
Acidity	0	2	2	2	2	2	1	2	2	2	2	2	2	2
Iron	.05	.05	.05	.05	.10	.05	.10	.10	.10	.10	.15	.10	.10	.10
Zinc *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copper *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sodium	2	2	2	2	1	1	2	2	2	2	1	2	2	1
Potassium	.7	.7	.7	.7	.5	.7	.6	.8	.6	.7	.5	.6	.8	.7
Calcium	6	6	6	6	6	6	6	6	6	6	6	6	7	7
Magnesium	1	1	1	1	1	1	1	1	1	1	1	1	1	1
pH	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.2	7.1	7.3	7.2	7.2	7.2	7.2

* The value 0.0 signifies a concentration less than 0.05 ppm.

Table 2. continued...

	ELIZA LAKE				CAVIAR LAKE			
	1		2		1		2	
	S	B	S	B	S	B	S	B
Total Solids	66	68	86	52	48	62	58	56
Susp. Solids	5	2	4	2	2	1	2	1
Diss. Solids	61	66	82	50	46	61	56	55
Turbidity	1.4	1.8	1.2	1.4	1.0	.7	.9	.9
Sulphates	5	6	<5	6	5	6	6	7
Free Ammonia	.00	.02	.02	.06	.03	.02	.14	.10
Total Kjeldahl	.40	.38	.38	.35	.36	.34	.38	.52
Nitrite	.002	.002	.002	.002	.003	.002	.002	.002
Nitrate	.00	.00	.00	.00	.00	.01	.00	.00
Total Phosphorus	.012	.012	.014	.014	.015	.018	.016	.016
Alkalinity	19	19	19	19	21	19	21	21
Acidity	2	2	2	2	2	2	2	2
Iron	.20	.20	.20	.15	.05	.10	.10	.10
Zinc	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lead	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sodium	1	1	2	1	1	2	1	1
Potassium	.7	.7	.7	.8	.8	.8	.8	.8
Calcium	7	7	8	8	8	10	9	10
Magnesium	1	1	2	1	1	1	1	1
pH	7.2	7.2	7.2	7.2	7.2	7.2	7.4	7.4

Table 3. Composition and abundance of phytoplankton collected from Atikwa, Eliza and Caviar Lakes on July 9, 1970. Results are expressed in areal standard units (a.s.u.) per millilitre.

	ATIKWA LAKE					ELIZA L.		CAVIAR L.	
	1	2	3	4	5	1	2	1	2
BLUE GREENS									
Anabaena	2	13	9	4	5	3	2	5	35
Anacystis	2		10	5	1				
Aphanizomen	8	10	9	2	10				
Gomphospheria						p	1		4
Oscillatoria	2			2	4	1	p		
Agmenellum	2			2	4			1	
FLAGELLATES									
Ceratium		6	13						
Chlamydomonas	25	21	104	90	65	7	8	26	21
Cryptomonas	14	10	8	3	5	2	3	6	8
Dinobryon	27	2	4	15	1	3	2	1	5
Euglena				5		4		4	6
Peridinium		1	4	1	2	2		3	
Lepocinclis		1	4				p		
GREENS									
Ankistrodesmus		1	2	1	1	p		1	
Coelastrum					1			2	
Cosmarium	1								
Dictyosphaerium		p							
Oocystis	1								
Pediastrum								2	
Scenedesmus	p	p	p		p		p	p	
Staurastrum	p			3				1	6
Botryococcus							1		
Crucigenia	1		1	1	1	1	2	1	3
Quadrigula	3		2			1			
Schroederia			p				p		p
DIATOMS									
Asterionella	51	39	7	26	6	9	5	88	117
Cyclotella	20	5	14	14	12	5	3	10	14
Cymbella			1			1			
Fragilaria								21	
Melosira	2	1	3	2	3	4	8	18	10
Navicula		p		3		1	4		
Nitzschia							2		
Stephanodiscus	2								
Synedra	9	5	9	10	2	5		37	33
Tabellaria	37	60	30	38	75	11	18	48	168
Rhizosolenia	1	2	6	2		p		1	2
Gomphonema						p			
Stauroneis							4		
Total a.s.u. per ml.	208	196	240	227	194	60	63	276	432

Table 4. Bottom fauna data secured from nine locations on Atikwa Lakes Chain - July 9, 1970. Results are expressed in number of organisms per square foot.

	ATIKWA LAKE					ELIZA L.		CAVIAR L.	
	1	2	3	4	5	1	2	1	2
MAYFLIES									
Ephemera			<1						
Hexagenia					4	7	4		
CADDISFLIES									
Oecetis					2				
Molanna					<1				
ALDERFLIES									
Sialis						2			<1
DIPTERA									
Tendipedidae	11	10	6	11	8	24	55	4	12
Chaoborus	23	12	22	9	4		<1	2	3
Heleinae					2	<1	11		
DECOPODA									
Mysis relicta						<1			
AMPHIPODA									
Hyalella azteca							<1		
Pantoporeia affinis	<1	13	14		<1			51	27
CLAM									
Pisidium								<1	
SNAIL									
Amnicola						2			
LEECH									
Helobdella stagnalis		<1							
WORM									
Oligochaeta	<1	4			<1		2	3	
MITE									
Unident.							1		<1